Superconducting Partnership with Industry: Readiness Review Update

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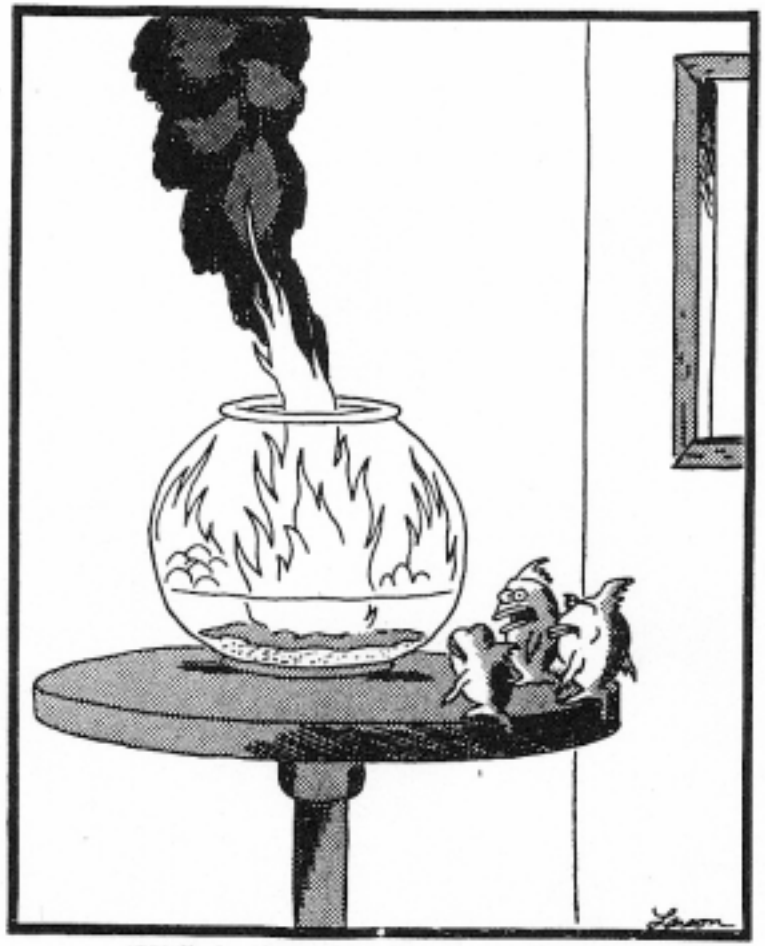
DOE 2004 Superconductivity Peer Review
July 27-29, 2004

SPI Readiness Review Program

- **Goal: enhance the probability of successful completion of SPI projects.**
- **The major tool is phased readiness assessments:**
  - **Focus is on early identification and resolution of technical issues**
    - issues involving cryogenic temperatures + high voltage are a major concern
  - **Performed by a small group independent of the SPI team being reviewed (from national laboratories, universities, consultants).**
  - **Emphasis is on an objective technical review: in-depth but not an audit nor confrontational.**
  - **Report goes directly back to SPI team with a copy to DOE only.**



"Well, thank God we all made it out in time. ... 'Course, now we're equally screwed."

Budget: $140 K/year from DOE
$40 K-LANL (3 cable projects)
$100 K-ORNL (all other projects)

Anticipate 3 reviews over an SPI time cycle

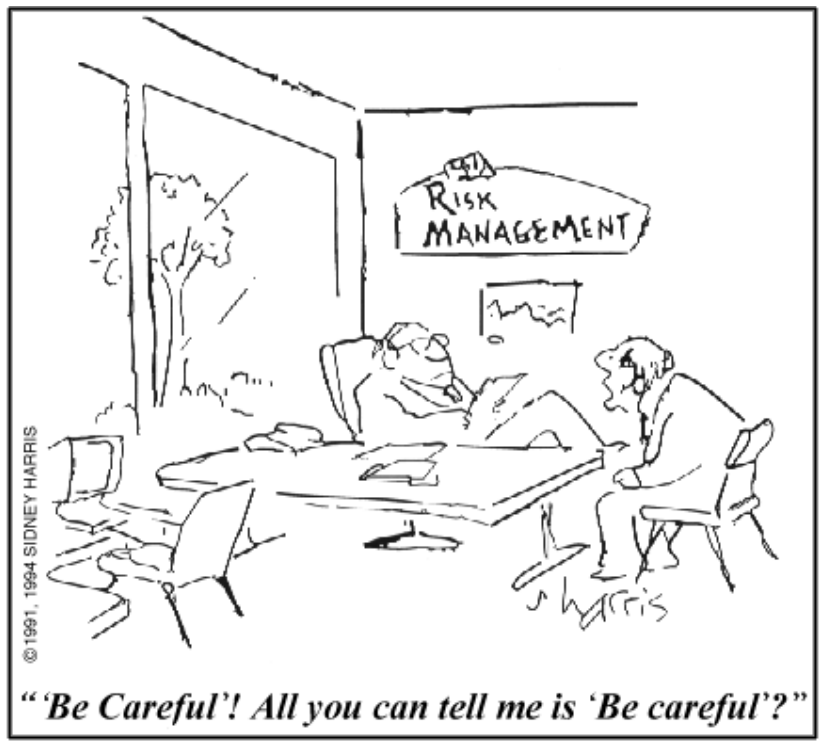
- **Phase 1**:
  - Shortly after the SPI award (typically during conceptual design), hold initial meeting to review the technical proposal and identify those system aspects potentially likely to repeat past problems or lead to new ones.
  - Identify resources and activities needed to address any potential problems.
    - Is the team organization/resources sufficient to address technical challenges?
    - Are incremental scaled-models and/or prototypes planned to reduce technical risks?
  - Meeting length – about 1 day.

Anticipate 3 reviews over an SPI time cycle

- **Phase 2**:
  - Prior to hardware procurement/fabrication (in the final design phase), review those critical areas where redundancy or back-up systems may be needed or where team prior experience may be limited.
  - Potential problem areas are vacuum system integrity, high voltage details, partial discharge, heat loads, unanticipated heating sources, thermal stresses, transient mechanical loads, etc.
  - Would require 1-2 days on-site with discussion of:
    - plans to prevent potential problems and
    - component/subsystem testing to qualify system prior to assembly.
  - Non-disclosure agreements will be signed by reviewers if required.

Anticipate 3 reviews over an SPI time cycle

- **Phase 3**:
  - Before system operation (for example, tie-in to the grid) do a final review to:
    - confirm that the phase-2 review concerns have been resolved
    - inspect the as-built hardware.
    - At this stage safety systems (to protect personnel and hardware) could be reviewed in some detail.
  - Look over project test plans to ensure completeness (for example, generation of data for technical standards for new technology).



"'Be Careful'! All you can tell me is 'Be careful'?"

Peer Review Interface

- At the annual DOE peer review:
  - Each SPI team should present “readiness” preparation activities in accordance with the revised evaluation criteria.
  - Only non-proprietary information will be presented.
  - Have asked the two cable projects that not being reviewed in the SPI sessions to present status of risk mitigation in the Tuesday morning overview session
  - Peer reviewers provide feedback on readiness review program implementation.

Relevant 2004 evaluation criteria

- **FY 2004 Performance/ FY 2005 Plans:** (SPI Panel: Included in this area for SPI projects is how the team is identifying, managing, and mitigating risks to a successful demonstration over the 2-year evaluation window.)

  FY 2004 Results: The presenter should identify major risks to a successful outcome, how they are mitigated (via a focused R&D program and/or redundancy, for example) and progress made during the last year on risk mitigation. (SPI Panel: Included in this area are results and recommendations from the phased SPI readiness reviews by the independent review team chartered by DOE.)

  Research Integration: Private sector presenters will describe how collaborations have accelerated their ability to overcome problems and mitigate risks in progressing towards commercial products and applications.

- **Bottom line**: How well is the team addressing technical risk mitigation?

2004 Results

- Four SPI readiness reviews in FY 2003
- Eight reviews to date in FY 2004
  - Four HTS cable project reviews
  - Two MFCL reviews (at SuperPower)
  - HTS Open Geometry MRI review
  - Flywheel electricity system with superconducting bearing review
- Reviews of the HTS motor project and 100 MVA Generator planned in August/September 2004

SPI Readiness Review 2004 Results

Project	Lead Company	Status (Jul 2004)	Reviews Done	Review Plans
HTS transformer 5/10 MVA	WES/ SuperPower	5/10 MVA tests complete	Test program 6/2003	Fall 2004: lessons learned
HTS motor 5000 HP	Rockwell	R&D		August 2004
Ultera long length HTS cable at AEP	Ultera (Southwire)	Design/ R&D/ prototypes	PDR: February 2004	
Reciprocating magnetic separator	DuPont	Magnet complete/ assembly	HTS solenoid CDR: 3/2003	TBD
Superconducting flywheel	Boeing	Testing @ 100 kW (Phase 2)	Oct 2003	
HTS 100 MVA generator rotor	GE	Design/R&D/ fabrication	CDR July 2003	PDR ~Sept 2004
Open MRI	Oxford Inst.	Design/ fabrication	CDR: Nov 2003	
Matrix fault current limiter	SuperPower	Design/R&D/ prototypes	CDR:Oct 2003 Tests: May 2004	
Long length HTS cable at LIPA	AMSC/ Nexans	Design/R&D/ procurement	CDR Nov 2003 Termination March 2004	
HTS cable at Albany (NYSERDA)	SuperPower/ SEI	Design/R&D / procurement	CDR Dec 2003	
Follow-on transformer R&D	WES	Under discussion		TBD

Cable Project Reviews

- LIPA AMSC-led cable project reviewed in November 2003 and March 2004 (termination only).
- Albany SuperPower-led cable project reviewed in December 2003
- AEP Ultera-led cable project reviewed in February 2004.

The SPI Cable "Readiness Reviews"

Steve Ashworth, LANL

Andreas Neuber, Texas Technical University

Joe Waynert, LANL

Roland George, DOE

Paul Bakke, DOE

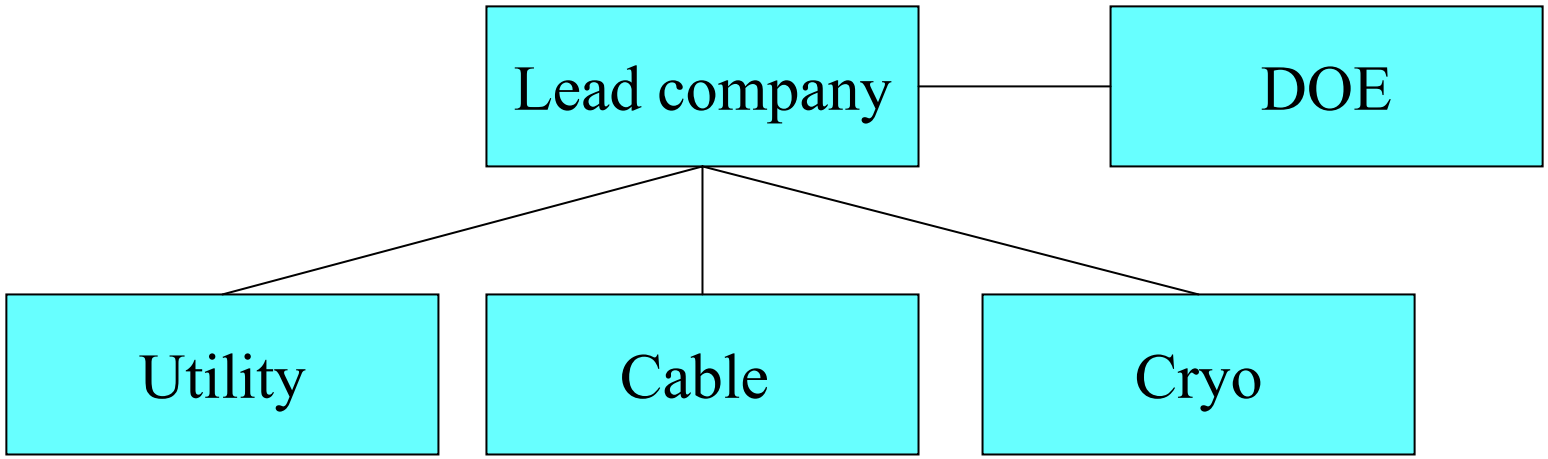
Cable Readiness Reviews

- Project overviews
- Background – why do reviews?
- Review process
- Reviewers ‘philosophy’
- Examples of this philosophy
- The ‘big’problems
- NOT included: discussion of ‘specific’ risk items - confidential

Why reviews? Past experience Detroit-Edison Cable

- Cable failed after installation
- Specific failure mode can be avoided in future
- This failure ‘haunts’ all SPI projects
- Learn from it and change system
- We cannot allow this to happen again!

Project structure not changed!



- How does DOE “see” into technical details of project
- Who questions technical details, requests further work
- Outside of company influence
- Review team can “see” everything

Is this openness a problem for SPI team?

- Everybody is ‘haunted’ by Detroit-Edison cable
- All teams realize “we cannot fail” this time
- Failure is worse than losing ‘IP’
- This has presented fewer problems than expected
- Credit to SPI ‘lead’ companies
  - They’ve had to sell this to their partners
- Sometimes material is ‘eyes only’, but it has always been provided when requested

The SPI Cable Projects

- Long Island Power Authority (LIPA) Project
  - American Superconductor
  - Nexans
  - LIPA
  - Air Liquide
- Albany Cable Project
  - Superpower
  - Sumitomo
  - Niagara Mohawk
  - BOC
- AEP Project
  - Ultera (NKT, Southwire)
  - AEP
  - Praxair
  - ORNL

Review Process

- 1 – 2 days on site
- Presentations on all aspects of project
  - Presentations by technical people not ‘management’
  - Detailed technical questioning
- Encourage as many people to attend from SPI Team as possible
- Significant output from the review is that everybody in the SDPI team gets to see everybody elses work
- Communication (see later!)
- Nothing “off limits”, no question too sensitive

Post-Review

- Project leader prepares “Risk management document”
- This is the most important ‘paper’ outcome of the review
- Captures all items raised by review panel
- Based on teams Internal Risk management procedure
- Emphasize review is only *part* of risk management
- Chair prepares report

Risk documents are different but fulfill requirements

Number	Requested by	Date submitted	Sub-system	Agreed response due date	Response by, Owner		Close Date
10/03-01	Ashworth Neuber	11/14/03	Cable Terminatio n	January 28, 2004	Nexans/ Schmidt		
10/03-02	Ashworth Waynert Neuber	11/14/03	Cable	January 28, 2004	Nexans/ Schmidt		
10/03-03	Ashworth	11/14/03	Cable	January 28, 2004	Nexans	Technical report on **	
10/03-04	Ashworth Neuber	11/14/03	Cable	Febuary 20, 2004	Nexans	Technical report on **	
10/03-05	Ashworth	11/14/03	Cable	to be discussed with Swarn#	AMSC, Nexans	Three phase electrical **	
10/03-06	Ashworth	11/14/03	Cable	March 31,2004	Nexans	** model	
10/03-07	Ashworth	11/14/03	Cable	January 28, 2004	Nexans	Over Ic conditions **	
10/03-08	Ashworth	11/14/03	Cable/Wire	June 30, 2004	AMSC/Masur	The statistical sampling plan is **.	
10/03-09	Ashworth	11/14/03	Cable	March 31,2004	Nexans	AC losses effect **	

- Small selection of risk items shown above from one review
- Comments are actually much more detailed, but confidential
- Document is updated by project leaders

Another example….

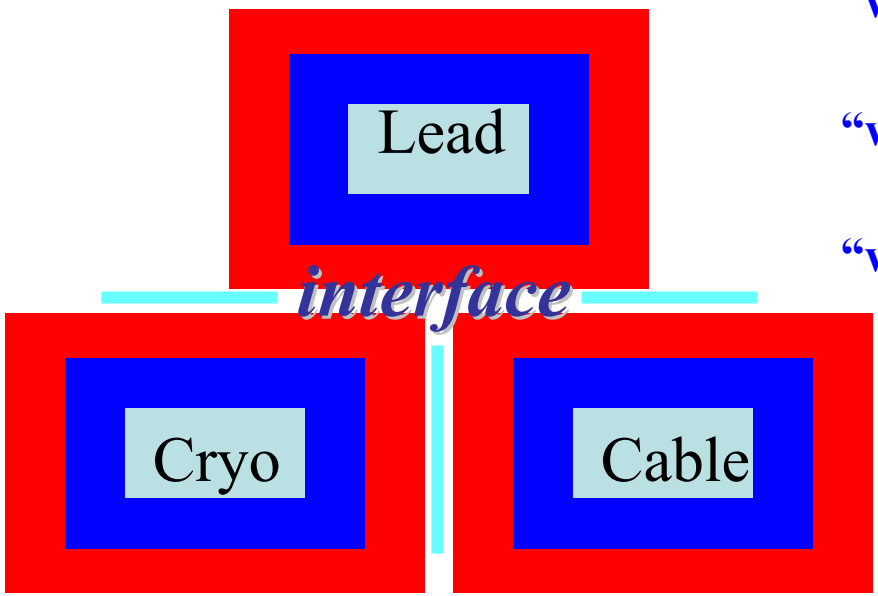
Tracking #	Code (see 'Key' sheet)	Reviewer	Comment	Assigned To	Priority/ Severity	1st Response Date	Resolution Date	Comments
12	C	Weynert	There should have been a presentation on the analysis of *****	SEI	B	2/9/04	Next RR meeting	
18	C	Weynert	Is there an issue with zero sequence network behavior *****	SEI	B	2/9/04	02/23/04	
27	C	Ashworth	Forces during cable installation***	SEI	C	2/9/04	Next RR meeting	
6-d	C/TERM	Weynert	Would like to see more modeling/results on... ****	SEI	B	2/9/04	Next RR meeting	SP suggests combining with #27
31	C	Ashworth	** 2-D electromagnetic model of the cable detailing ***	SEI	B	2/9/04	03/05/04	
51	C	Neuber	Establish that the mechanical stress on the terminations ****	SEI	B	2/16/04	Next RR meeting	
9	C/TERM	Weynert	The differential thermal contraction of ****	SEI	B	2/16/04	Next RR meeting	SP suggests combining with #51
8	FC	Weynert	** there may be breakdown if **	SEI	A	2/16/04	Next RR meeting	
6-a	C/TERM	Weynert	Would like to see more modeling/results on **	SEI	B	2/16/04	Next RR meeting	SP suggests combining with #8

Reviewers Philosophy and Program Structure

- These companies know what they're doing
  - WHEN they're in their area of expertise
- Look for companies operating outside their area
- Look at the interface

"we have an expert in house who designed it"

"we've made one before and it worked"



"we have a person who knows something about this"

"we subcontracted it out, and they've done similar things"

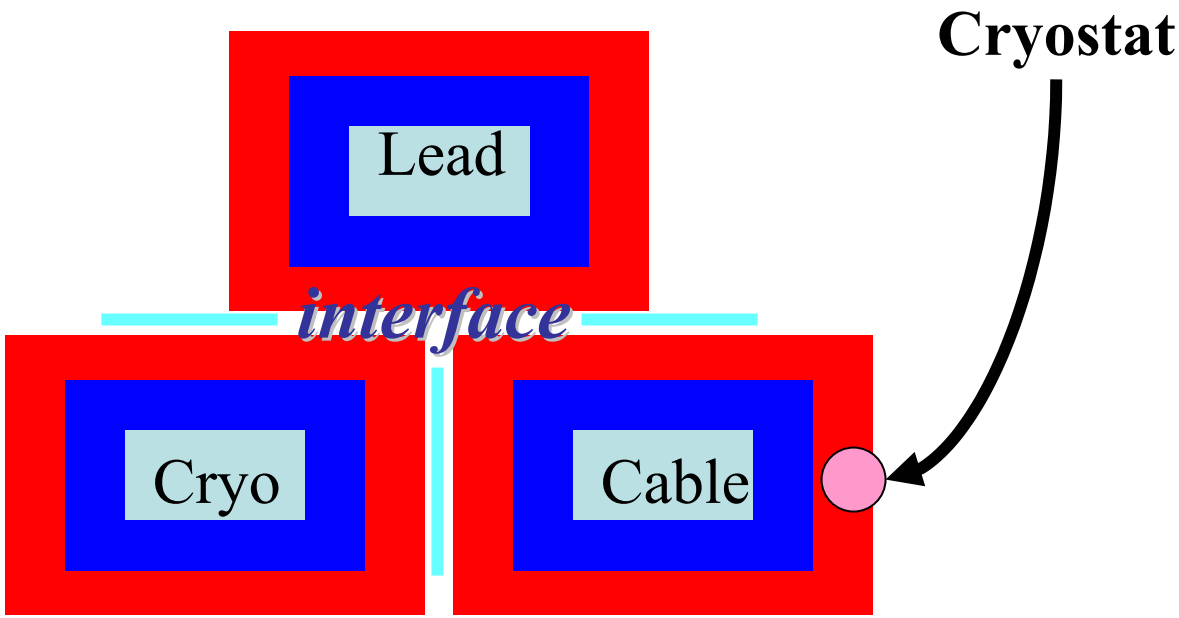
"we have an acceptance / test plan

"it's a new area for us"

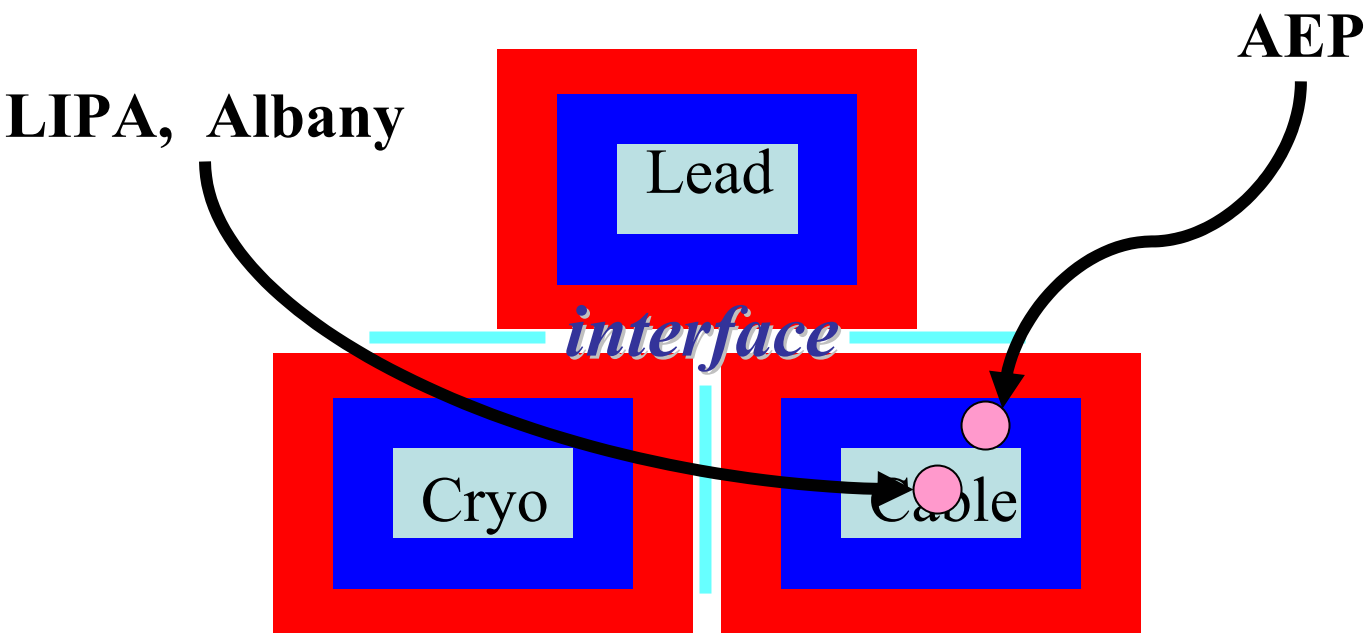
"we don't have in-house expertise"

"we don't have a formal acceptance / test plan"

Failure item in Detroit-Edison was outside all ‘cores’ and visible only to one partner



That specific risk now reduced. Cryostats are being manufactured by Nexans and Sumitomo. Both have track record and experience



Partners now have more visibility into each others work.

Due in part to review process

Examples of things that can go wrong at interfaces

Detroit-Edison Frisbee substation, August 03

- Trying to loosen bolt on bus bar system
- DE worker provides wrench
- ½" wrench fits 12mm bolt quite nicely
- Until you put force on it, then it slips
- Painful mashed knuckles into copper bus bar

Teams have been told

"know where mm end and inches begin"

Example of things that *will not* go wrong at interface. #1

- Cryo company providing LN plant.
- Experienced in building, operating, maintaining complex LN system
- Sensors, computers, actuators – state of the art
- Reviewer: “have you ever operated a LN plant in multi-kV environment?”
  - Sensors mV?
  - Computers ???

Review showed that this item was incorrectly assumed to be in ‘core’ of team member,

needed more thought

Example of things that *will not* go wrong at interface. #2

- Reviewer Question "LN dielectric integrity *after* a fault ? "
- Answer (Cable co:) "not important, breaker open, voltage goes away"
- Voice (Utility) "er…actually..we only disconnect at one end – cable can still have voltage"
- Discussion follows….
- "two breakers…linked, disconnect both ends…no voltage"
- Voice (Utility) "er…charging voltage stays until drained…"

Review stimulated communication through interface within group

Where are the greatest risks?

- Fault Currents
  - These are driving cable designs
  - Outside limits of experience
  - Not able to test adequately
- Thermal contraction
  - LIPA cable will contract over 20 feet!
  - Companies being very creative in solutions
  - Philosophy: “solve for now” or “solve for ever”?
- Cryostat
  - Damage on installation
  - Lifetime?

What's wrong with the process?

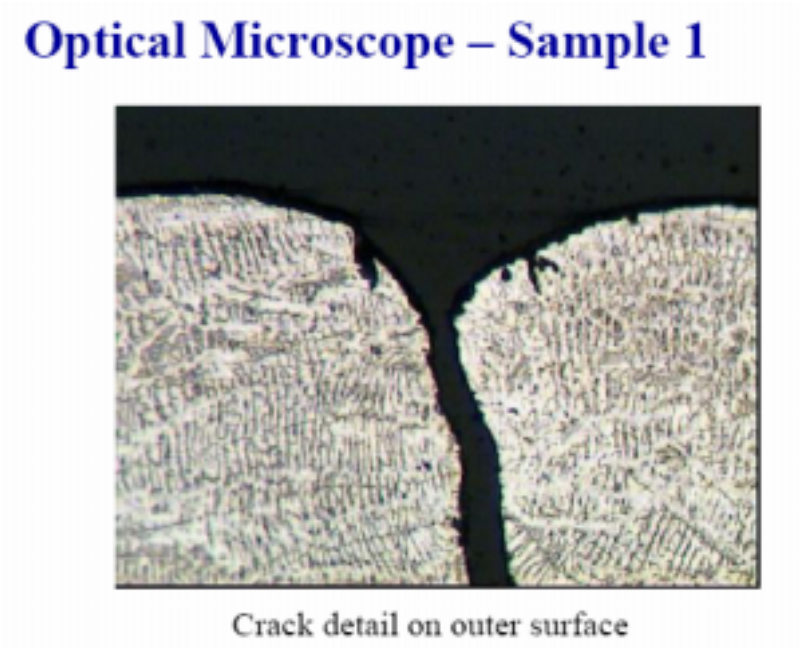
- Lots of common problems
  - sometimes 3 solutions!
  - Cannot all be the 'best' solution
  - All should work !
  - Reviewers CANNOT pass solutions along
  - Reviewers DO ensure that common concerns are passed along!
- Only three reviews in project lifetime
  - Perhaps too much is happening between reviews
  - We are trying to keep updated but..
  - Closer contact perhaps (short monthly update?)

Continuing concerns? Test Plans

- Approaching “Final design”
- Number of ‘risk items’ need resolving
- Teams all have test plans (short sections)
- Ask each team to ensure testing is integrated with ‘risk document’. Catch everything
- Will be discussing expanding testing
- Is “qualification” appropriate
  - Certainly for ‘voltage’ on cable and termination
  - How about ‘current’, bend?

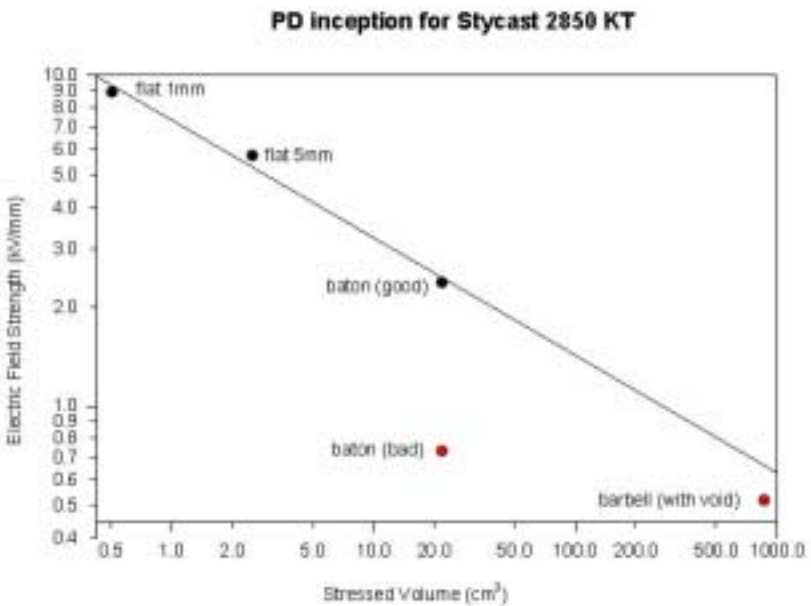
HV issues on past projects

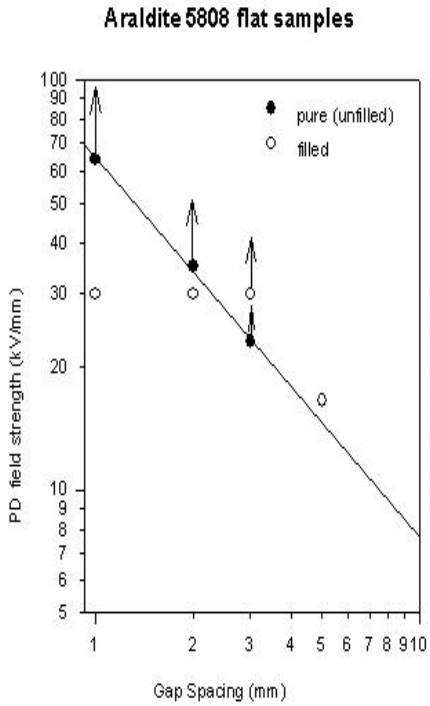
- **Project 1** "…it would seem likely that the primary cause was a local increase in (vacuum) pressure which drove the operating conditions towards the minimum of the Paschen curve which resulted in a loss of dielectric integrity."
- **Project 2** "Flexible cryostat is manufactured with the in-line welding and corrugating technique. T.I.G. welds ensure leak proof welded tube."
  - *"Several micro-cracks detected in inner corrugated tube"*
  - *"Analysis also suggests material characteristics contributed to defect origins rather than solely welding process anomalies"*
  - *"Weak spots may have turned into complete fractures upon the further mechanical stress of installation"*

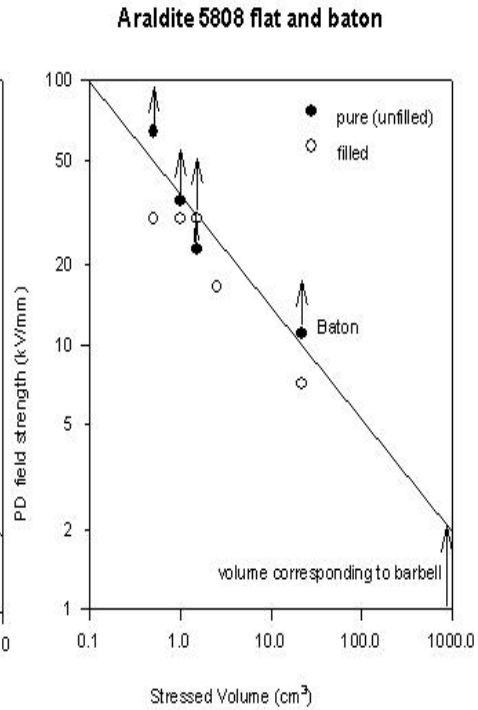


HV issues on present projects

- **Project 3**
  - "All 3 phases exhibited PD inception at very low voltages"
  - "Dielectric failure at less than rated voltage"
  - "All three phase sets failed in different places"
  - "Epoxies generally lose strength for large stressed volumes; problem is worse when defects such as bubbles are present; scaling with volume generally not known for most materials"
- Data from **Project 4**:







SUPERCONDUCTIVITY FOR ELECTRIC SYSTEMS

2005 Plans

- **All of the SPI projects will have been through at least one review cycle by August 2004. For 2005:**
  - At least one review per project is planned in 2005 and 2006 as the SPI projects proceed to initial commissioning.
- **We are encouraging all the SPI projects to develop risk identification and mitigation processes such as failure mode and effects analysis (FMEA) to manage risks.**
  - Will review each project's risk mitigation plans in 2005
- **In 2005 a web-site will be implemented that will have:**
  - lessons-learned from prior SPI projects
  - some general design guidance on high voltage, vacuum, etc. and
  - a place where SPI participants can post comments or questions and get feedback.

2005 Plans (continued)

- **Based on continuing issues with the performance of dielectric materials at cryogenic temperatures and at high voltage, more emphasis is needed on R&D and design guidelines in this area for the grid-based SPI projects.**
- **A High-Voltage Cryogenic Dielectric Workshop is being considered; it could be held just after the 2005 Wire Development Workshop.**
  - **Participation by each SPI team facing high voltage component qualification would be expected and the agenda could include some overview talks on liquid nitrogen dielectrics, solid dielectrics, HV design practices, etc.**

Research Integration

- **Since the reviews contain a large amount of proprietary material, the results and recommendations are typically shared only between the project being reviewed, the reviewers and DOE.**
- **The reviewers, to the extent possible, highlight or flag potential problem areas that they have learned from other project reviews.**
- **The proposed web-site and workshop will be a way to share generic lessons-learned and design information.**
- **Have engaged review staff from 2 DOE labs, 1 DOD lab, a university and outside consultants to leverage expertise.**